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The following publications were taken into consideration for the determination of patentability:

DE 42 38 957 A1
DE 39 33 320 A1
DE 37 30 265 A1
US Pat. No. 4,630,265

Title in German of the object of the invention:
Verfahren zum Betrieb eines asynchronen und redundanten Serienbusses

METHOD FOR THE OPERATION OF AN ASYNCHRONOUS AND REDUNDANT SERIAL BUS

(57) German PTO/UJK

The invention pertains to a method for the operation of an asynchronous and redundant serial bus, consisting of n > 1 parallel, independent lines, whereby there are provided at least

two multiplexers, which can be synchronized with one another, which are suitable for the bidirectional transfer of data [pieces of data information] between a serial bus interface and one of the parallel lines.

The invention is characterized in that

- a preferred line of the redundant serial bus is designated or allocated as primary bus, and the n-1 remaining lines are allocated as replacement [alternate] buses.

- in the case of undisturbed data communication traffic, data [pieces of data information] are exchanged between the operating systems' stations - which are connected by means of the multiplexers - by means of the primary bus, and control data [pieces of control information] is exchanged between the multiplexers by means of at least a presettable bus,

- when the quality of the data transfer on the active bus deteriorates below a presettable limit, an error message is relocated onto a superordinated or higher-order entity, and the deactivated bus is analyzed, and

- when the quality of data transfer on the primary bus improves above a presettable limit, the primary bus is reallocated as active bus. □German PTO/□JK

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Description

The invention pertains to a method for the operation of an asynchronous, redundant serial bus in accordance with the preamble of patent claim 1.

From the publication " Automatisierungstechnik", R. Oldenburg Publishers, Vienna, 1992, vol. 1, p 406, it is known that in a redundant bus system - when a switchover or changeover criterion occurs - the data communication traffic is switched over or changed over from the active bus into a passive bus whereby the respective active bus represents a presettable selection of analogous buses, having equality of access, of the redundant bus system. Breakdowns or malfunctions of the active bus and cyclical interrogation or extraction of the difference of the transfer requests on the active and the passive bus are provided as switchover or changeover criterion.

Moreover, from the DE 39 33 320, there is known a device for the acquisition and processing of electric signals, which consists of two analogous contraptions, which are redundantly connected to the peripheral components by means of data lines (data circuits), and are mutually excluded from the transmit-side data communication traffic. Taking as a point of departure a random or stochastic initialization assignment, the faulty result of an automatic test routine is provided as changeover criterion.

Inherent to both systems is the fact that the bus system is always designed as completely redundant, and all bus-users should mandatorily have at their disposal or be equipped with redundant

connections because the switchover or changeover criteria do not allow a temporal determination of the reactivation of the originally active bus after fault recovery or debugging.

Moreover, the error correction on the active bus always originates with the existing static errors. However, especially in the case of asynchronous buses, transient errors occur contingent, e.g., upon the bus loading, which errors lead to the circumstance that a physically intact bus appears as faulty or defective.

In addition to this, the request profile exists for the redundant embodiment of the data path, customarily only for selected stations of a bus system, for which a high availability potential of the data path is required.

In DE 37 13 825 A1, a highly available bus system is cited, in which with the help of at least two bus lines the relevant identical message is serially transferred. As ensues from column 1, line 39 thru 60, column 2, lines 2 thru 8 and column 12 thru 33, and from claim 1 of that "Offenlegungsschrift", both data transfer paths are continuously monitored, i.e. it is continuously checked or verified which of the transfer paths is error-free (correct). By means of a detection logic, the bus lines are checked whether a certain error-detection character is transferred. Out of it, a suitable changeover criterion is generated.

In US Pat. No. 4,630,265, a redundant bus system is claimed,

which can consist of a multiple number of buses. In accordance with column 2, lines 14 thru 32, and claim 1, reference is made to a time window as changeover criterion for the selection of the best bus, in which time window the transferred data satisfy or comply with a preset algorithm.

Finally, from DE 42 38 957 A1, Fig. 1 with the description, a data transfer system is known, in which - on the one hand - processing units 40 are connected to serial, parallelly running buses 50, 60, or 70, and - on the other hand - processing units are connected to a system bus 20 and to lateral buses 30, whereby the system bus 20 has a nonpersistent access behavior, while the lateral buses should have a communications protocol, having priority-persistent access behavior, compare column 3, line 8 thru column 5, line 17, and claims 1 and 2.

The objective to operate in such a way an asynchronous, and redundant bus system that a maximum possible availability of the data path is materialized for redundantly connected as well as for non-redundantly connected stations forms the basis of the invention.

In accordance with the invention, the objective thus set is achieved with the means of patent claim 1., Embodiments o the invention are described in patent claims 2 thru 4.

By means of an exemplified embodiment, the invention is described in greater detail as follows. The drawing belonging to the exemplified embodiment shows in:

Fig. 1 - a diagrammatic representation of the selective interface connection of stations to a redundant bus system.

The method in accordance with the invention pertains to structures, as they are described in an exemplified way in Fig. 1, and is elucidated as follows by means of the diagrammatic representation. Preset or specified are stations 21 thru 26, which are interconnected or cross-linked by means of a bus system 1. The requests or demand for availability of a transfer or transmission path - which can be materialized by means of bus system 1 - between the individual stations 21 thru 26 is high to a different extent for different stations 21 thru 26. According to the availability requests [demand] for transfer path, the bus system 1 consists of a multiple number n > 1 of parallel, independent lines 11 thru 1n, whereby each line 11 thru 1n is a serial bus.

In order for the stations 23 thru 26 to be connected to a multiple number of lines 11 thru 1n, there are provided multiplexers 33 thru 36, which are suitable for the bidirectional transfer of data [pieces of data information] between a serial bus interface 43 thru 46 and one of the parallel lines 11 thru 1n. The multiplexers 33 thru 36 can be synchronized with one another, i.e. all multiplexers 32 through 36 connect the relevant serial bus interface 43 thru 46 to the same available line 11 through 1n of the bus system 1.

The stations 24 and 25, having highest requests [demand] for

the availability of the transmission path can be connected to all lines 11 through 1n of the bus system by means of the multiplexers 34 and 35. With decreasing availability requests of the stations for the transfer path, the access opportunity to the lines 11 thru 1n of the bus system is quantitatively reduced. Thus, the stations 23 and 26 can be connected only to the lines 11 and 12. In such a way, a hierarchically structured bus system can be represented by means of the availability request, in the case of which hierarchically structured bus system the number of the connected stations 23 thru 26 is inversely proportional to the availability of the connected data paths.

In accordance with the invention, a line 11 is designated as primary bus for the operation of a bus system 1 of this kind.. The primary bus is the preferred line of the bus system 1, to which all stations 21 thru 26 are connected either directly or by means of multiplexers 33 thru 36. All other n - 1 lines 12 thru 1n are designated or allocated as replacement [alternate] lines.

In the case of a undisturbed data communication traffic, data [pieces of data information] are exchanged between the stations 21 thru 26 by means of the primary bus 11 as active bus. Moreover, control data are exchanged between the multiplexers 33 thru 36 by means of at least a presettable bus. In doing so - in a separate embodiment of the invention - all replacement buses 12 thru 1n as well as the primary bus 11 are cyclically preset for the transfer of control data. In doing so, the transfer quality

on the preset bus is continuously monitored.

If the quality of data transfer on the active bus deteriorates under a presettable limit, a preset replacement or alternate bus is allocated as active bus, an error message [fault indication] is relocated onto a superordinated (higher-order) entity, and the deactivated bus is analyzed. In hierarchically structured bus systems, in which the parallel lines 11 thru 1n differ by the number of the connected stations 21 thru 26, the next higher hierarchy level is preferably preset as replacement [alternate] bus.

If the active bus is the primary bus 11, changeover or switching is carried out to line 12 as replacement [alternate] bus, when the data-transfer quality on the active bus deteriorates. Now, if the data-transfer quality on the line 12 as active bus also deteriorates below the preset limit, the next line up to the line 1n is designated or allocated as the active bus.

If the data-transfer quality on the primary bus 11 exceeds a presetable limit, the primary bus 11 is reallocated as the active bus. If the data-transfer quality of a deactivated replacement bus on a lower hierarchy level exceeds the presettable limit with respect to the active bus, the deactivated replacement [alternate] bus is reactivated, and reallocated or reassigned as the active bus.

In order for the data-transfer quality to be determined,

monitoring - by means of transferring data - is carried out on at least the active bus and the primary bus for the completeness and accuracy of the data, which are transferred data. Moreover, a selection out of the number of the transferred information units per unit time, the number of the collisions per unit time and the number of the repetitions when an information unit is transferred, is monitored.

By means of permanent monitoring of the quality of the data transfer and its quantitative evaluation, transients of static malfunctions* [*Translator's note: Or all failures, interferences, disturbances or those accidental conditions, which cause a functional unit to fail to perform its required function] of the data communication traffic can be discerned. When a transient malfunction ceases to exist, this [new condition] can therewith be taken into consideration as changeover criterion for the determination of the active bus. By predetermining of a preferred line as primary bus, which is always allocated as active bus, when the transfer quality above the preset limit allows this, it is possible to operate non-redundantly connectable stations 21 and 22 and redundantly connected stations 23 thru 26 on the same redundant bus system 1, and to place at the disposal of each connected station 21 thru 26, corresponding to its hierarchical line [connection] characteristic, a transfer path, which is available to the maximal possible extent.

In an especially advantageous way, the redundancy of the

bus system 1 can be scaled, and matched to the availability of the connected stations 21 thru 26. In additon to this, the method in accordance with the invention provides an opportunity for subsequent redundancy complements in existing bus systems, without a necessity to intervene into the sequence of the bus allocations.

Patent Claims

1. Method for the operation of an asynchronous and redundant serial bus, consisting of n > 1 parallel, independent lines, there are provided whereby at least two multiplexers, synchronized with one another, which are suitable for the bidirectional transfer of data between a serial bus interface and one of the parallel lines, **characterized in that**

a preferred line of the redundant serial bus and the n - 1 remaining liens are allocated as replacement [alternate] buses,

- in the case of undisturbed data communication traffic, data [pieces of data information] are exchanged between the stations - which are connected by way of the multiplexers - by means of the primary bus in its capacity as active bus, and

control data are exchanged between the multiplexers by means of at least one presettable bus,

- when the quality of the data transfer on the active bus deteriorates below a presettable limit, a presettable alternate bus is allocated as active bus, an error message is relocated onto a superordinated entity, and the deactivated bus is analyzed, and

- and when the quality of the data transfer on the primary bus exceeds a presetable limit, the primary bus is reallocated as the active bus.

2. Method as claimed in claim 1, characterized in that at least the active bus and the primary bus are continuously monitored by transferring of control data.

3. Method, as claimed in claim 1, characterized in that in order for the quality of data transfer to be determined or ascertained, the completeness and the accuracy of the transferred control data is constantly monitored at least on the active bus and the primary bus, and a selection out of the number of the transferred units of information per unit time, the number of the collisions per unit time and the number of the repetitions when an information unit is transferred, is monitored.

4. Method as claimed in claim 3, characterized in that as a result of quantitative evaluation of the monitored and registered parameters, defining the quality of the data transfer, transients of static malfunctions of the data communication traffic can be

discerned.

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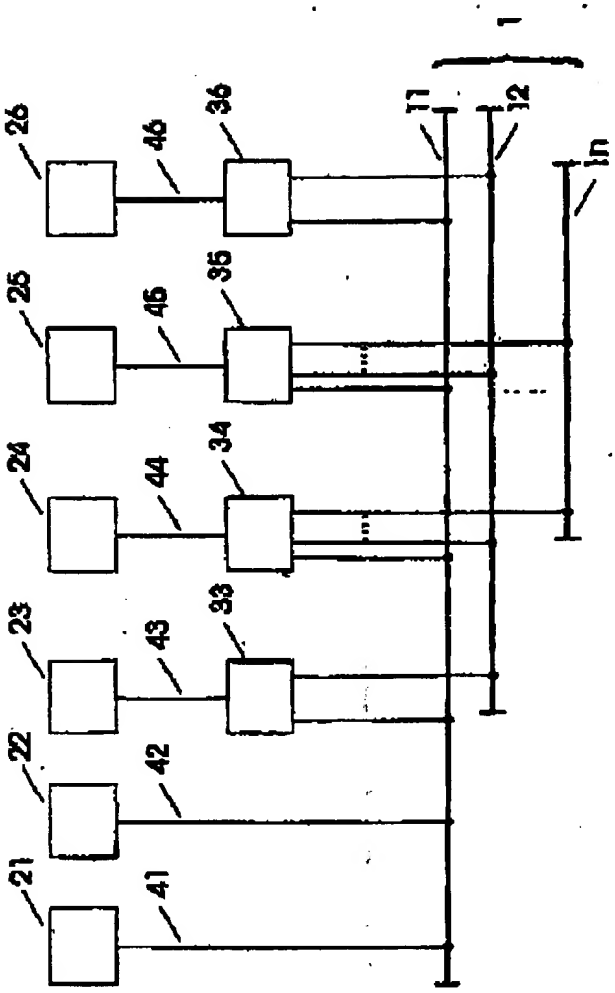

Fig. 1

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